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January 10, 2000

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Assistant Commissioner for Patents
Washington, D.C. 20231

PCT/FR99/01105
-filed May 10, 1999

Re: Application of Gerard CAILLE, Beatrice PINTE, Jacque GRAFFEUIL, Jean-Guy
TARTARIN, Thierry PARRA
A CIRCUIT FOR AND A METHOD OF RECEIVING OR TRANSMITTING
MICROWAVES
Our Ref: Q057408

Dear Sir:

The following documents and fees are submitted herewith in connection with the above application for the purpose of entering the National stage under 35 U.S.C. § 371 and in accordance with Chapter II of the Patent Cooperation Treaty:

- ☒ an executed Declaration and Power of Attorney.
- ☒ an English translation of the International Application.
- ☒ 6 sheets of formal drawings.
- ☐ an English translation of Article 19 claim amendments.
- ☐ an English translation of Article 34 amendments (annexes to the IPER).
- ☒ an executed Assignment and PTO 1595 form.
- ☒ a Form PTO-1449 listing the ISR references, and a complete copy of each reference.
- ☒ a Preliminary Amendment

**PLEASE SEE THE ATTACHED PRELIMINARY AMENDMENT BEFORE
CALCULATING THE FEE**

The Government filing fee is calculated as follows:

Total claims	19	-	20	=		x	\$18.00	=	\$0.00
Independent claims	2	-	3	=		x	\$78.00	=	\$0.00
Base Fee									\$840.00

TOTAL FILING FEE	<u>\$840.00</u>
Recordation of Assignment	<u>\$ 40.00</u>
TOTAL FEE	<u>\$880.00</u>

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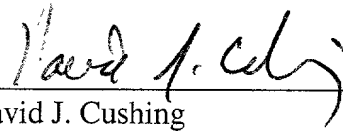
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January 10, 2000

Checks for the statutory filing fee of \$840.00 and Assignment recordation fee of \$40.00 are attached. You are also directed and authorized to charge or credit any difference or overpayment to said Account. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16, 1.17 and 1.492 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from May 15, 1998 based on French Application No. 9806201.

Respectfully submitted,


David J. Cushing
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Date: January 10, 2000

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Gerard CAILLE, et al.

PCT/FR99/01105

Attorney Docket Q57408

Appln. No.:

Group Art Unit:

Filed: January 10, 2000

Examiner:

For: A CIRCUIT FOR AND A METHOD OF RECEIVING OR TRANSMITTING
MICROWAVES

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION:

Page 1, after the title, insert the heading --Background of the Invention--.

Page 3, before line 20, insert the heading --Summary of the Invention--.

Page 5, after line 12, insert the heading --Brief Description of the Drawings--.

after line 31, insert the heading --Detailed Description of the Invention--.

IN THE CLAIMS:

Claim 3, line 1, delete "or claim 2".

Claim 4, line 1, delete "any of claims 1 to 3" and insert --claim 1--.

Claim 5, line 1, delete "any preceding claim" and insert --claim 1--.

Claim 8, line 1, delete "any preceding claim" and insert --claim 1--.

Claim 10, line 1, delete "any preceding claim" and insert --claim 1--.

PRELIMINARY AMENDMENT
Attorney Docket Q57408

- Claim 11, line 1, delete "claims 5 and 10" and insert --claim 10--.
- Claim 13, line 1, delete "any preceding claim" and insert --claim 1--.
- Claim 14, line 1, delete "any preceding claim" and insert --claim 1--.
- Claim 15, line 1, delete "any preceding claim" and insert --claim 1--.
- Claim 16, line 1, delete "any preceding claim" and insert --claim 1--.
- Claim 17, line 1, delete "any preceding claim" and insert --claim 1--.

IN THE ABSTRACT:

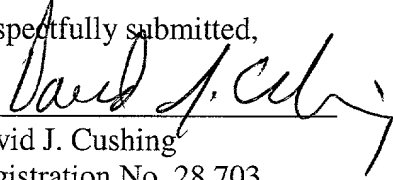
After the heading "Abstract" delete the title.

REMARKS

Entry and consideration of this Amendment is respectfully requested.

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A CIRCUIT FOR AND A METHOD OF RECEIVING OR TRANSMITTING
MICROWAVES

The invention relates to a circuit for and to a
method of receiving and/or transmitting microwaves.

5 Transceiver circuits are routinely used in
telecommunications systems. They are usually intended to
transmit high powers and to receive low powers. This
applies to telecommunications systems in which the
signals are relayed by geostationary satellites, for
10 example.

In such systems, the transmit frequencies and the
receive frequencies are different to prevent the transmit
signals interfering with the receive signals. It is also
necessary to provide filter means so that the required
15 frequency can be received or transmitted on each channel
and the frequency of the other channel eliminated. The
signals must be particularly carefully separated when
transmission and reception are simultaneous.

Such systems usually include waveguide circuits and
20 a waveguide source and a duplexer with a high rejectivity
in the transmit and receive bands, respectively. They
are therefore bulky, which may not be suitable in all
applications, in particular in telecommunications systems
terminals in which each user must be provided with a
25 transceiver.

In particular, microwave transceiver circuits are
routinely used for domestic and professional applications
in satellite telecommunications systems.

30 Telecommunications systems of this type are being
developed for "multimedia" applications, for example.
Such systems include a constellation of satellites in low
Earth orbit, at an altitude of 800 km to 1500 km, or
medium Earth orbit, at an altitude of 6000 km to
12,000 km. These orbits are "low" and "medium" in
35 comparison with the orbit of geostationary satellites at
an altitude of 36,000 km. The role of the satellites is
to provide communications between terrestrial users. The

calls transmitted in this way are multimedia calls, i.e. they convey TV, audio and video signals, digital data of all kinds, programs, telephone signals or facsimile signals. Compared to calls relayed by geostationary
5 satellites, the low altitude of the satellites reduces the distance the call has to travel and therefore the propagation time delays, which facilitates interactivity in such systems. Furthermore, with constellations of satellites it is possible to optimize the coverage, for
10 example by concentrating resources in areas of high population density, whereas a geostationary orbit concentrates resources in areas near the equator.

A terrestrial user can communicate with a satellite only when the satellite is "in view"; this is generally
15 for a period in the order of twenty minutes. It is therefore necessary for the user's antenna to be able to track the satellite as it moves overhead and for the user to be able to switch the call instantaneously to the next satellite, which is coming into their field of view at
20 the same time as the present satellite is moving out of their field of view. Instantaneous switching is needed above all for interactive calls for which any interruption of service, however short, is unthinkable. To solve this problem, a transceiver device with two
25 antennas is generally provided, one antenna moving to track the satellite with which the user is communicating and the other at the ready and pointing towards the beginning of the field of view of the next satellite.

Transceiver devices, and in particular their
30 antennas and associated circuits, intended for such telecommunications systems must be particularly light and small in order to facilitate movement and installation on the roof of a building (in particular a private house) and thereby avoid an undesirable aesthetic effect.

35 Furthermore, it can be advantageous to associate the two transceiver devices and associated circuits with a common focusing lens. In this case, the two devices and

their circuits must coexist in a limited space, which reinforces the need for these devices and circuits to be small in size and light in weight.

Given the above conditions, it is hardly feasible to use waveguide technology, which is heavy and bulky. A planar technology is therefore used, that most widely employed being referred to as the "microstrip" technology. However, with this technology, solutions known in the art to the problem of isolating transmission and reception cause high losses which degrade link quality or make it necessary to increase the size of the antenna. This is the case in the device described in document EP 0 744 831.

It is necessary to provide filters with a high level of attenuation (high rejectivity) to eliminate transmit frequencies in the receive band and receive frequencies in the transmit band. However, low-noise filters with a high rejectivity are difficult to implement in planar technology.

The invention overcomes this drawback.

It enables simple and low-noise implementation of microwave transmit and/or receive circuits using planar technology and with excellent isolation between the transmit and receive circuits.

The circuit for transmitting and receiving microwaves in accordance with the invention is characterized in that the receive circuit includes at least two filter and amplifier stages connected to the radiating means and respectively comprising a planar filter whose rejectivity for transmit frequencies is a fraction, preferably a small fraction, of the total rejection needed to eliminate the transmit frequencies and an amplifier whose gain is a fraction of the total gain of the circuit, said filter and amplifier stages applying progressive filtering and amplification.

The rejectivity of the filter of this stage is preferably chosen so that the amplifier is not

delinearized by residual transmit signals.

The additional rejection is provided by at least one other planar filter and amplifier stage.

5 In the radiating device, the noise caused by filtering is principally a function of the noise introduced by the first filter connected to the radiating device, the noise contributed by the other filter(s) being negligible in practice because it is reduced in proportion to the gain of the amplifiers between the
10 other filter(s) and the radiating device.

Accordingly, the noise level is moderate because the rejectivity of the first filter is moderate.

A filter with moderate rejectivity is simpler and cheaper to implement than a filter with high rejectivity.

15 In particular, relatively inexpensive substrates can be used, such as substrates with a matrix of flexible organic material, for example PTFE, whereas filters with a high rejectivity generally require alumina substrates.

It is preferable if the transmit circuit is an
20 analog circuit, i.e. if it is implemented with at least two stages connected to the radiating device and respectively comprising a planar filter whose receive frequency rejectivity is equal to a fraction (preferably a small fraction) of the rejectivity needed to eliminate
25 receive frequencies and an amplifier whose gain is only a fraction (preferably a small fraction) of the total gain of the circuit.

Note that here the expression "planar technology" refers a technology in which the components are
30 implemented in a plane form, in particular the "microstrip" technology. In this case, a substrate 0.5 mm to 2 mm thick is used whose bottom earth plane is glued to the bottom of a metal casing. The "suspended triplate" technology can be used instead. In this case a
35 substrate 0.15 mm to 0.5 mm thick is used and its non-metallized bottom face is clamped between two metallic half-shells. With this latter technology, most of the

microwave energy propagates in the air above and below the substrate, which causes lower losses than the microstrip technology. However, the circuits are larger.

From the point of view of implementing the circuits, the two technologies are virtually identical, and only the effective dielectric constant ϵ_e may differ from one to the other. As a result the wavelengths can also be different, given that the wavelength is related to the effective dielectric constant ϵ_e by the following equation, in which c is the speed of light and f is the frequency:

$$\lambda = c/f \cdot \sqrt{\epsilon_e}$$

Other features and advantages of the invention will become apparent from the description of some embodiments of the invention given with reference to the accompanying drawings, in which:

Figure 1 is a diagram showing the use of a transceiver device in accordance with the invention in a non-geostationary satellite telecommunications system,

Figure 2 is a diagram showing an antenna comprising two transceiver devices of the invention and used in a satellite telecommunications system,

Figure 3 is a diagram of part of a transceiver device of the invention,

Figures 3a and 3b are diagrams analogous to that of Figure 3 showing variants of the invention,

Figure 4 is a sectional diagram showing a transceiver device and circuit of the invention,

Figure 5 is a diagram showing transceiver circuits of the invention, and

Figure 6 shows one embodiment of receiver circuits.

In the telecommunications system shown in Figure 1, a set of satellites 10, 12 occupies an orbit 14 at an altitude of approximately 1 000 km to 1 500 km above the surface 16 of the Earth. Each satellite includes transceiver means for relaying a call between terrestrial users and stations providing access to specific services,

such as databases. Figure 1 therefore shows a user terminal 18 which sets up an interactive call with another user or an Earth station (not shown) via the satellite 12. The interactive nature of the call is symbolized by a double-headed arrow 20 on the path of the electromagnetic waves between the antenna 22 of the satellite 12 and the antenna 24 of the user 18.

The antenna 24 is on the roof of a private house, for example. It has a focusing, for example spherical, surface 26, as shown in Figure 2, and two radiating elements 28, 30 which can move over the focal surface 26 of the antenna 24.

The radiating element 28 tracks the satellite 12 which is currently in view and the radiating element 30 is in a waiting position and continues to point towards the area in which the next satellite will appear. The radiating element 30 takes over from the element 28 when the satellite 12 leaves the field of view of the antenna and the next satellite enters it. The switching from the element 28 to the element 30 can be instantaneous.

In the example shown in Figure 1, a control unit 32 on the premises of the user 18 tracks the satellites, controls the transmission and reception of signals and possibly decrypts the signals. The control unit is connected to a microcomputer 34 or the like including memory which stores information relating to the positions of the satellites so that the motors can be caused at any time to move the radiating elements 28 and 30 to point them accurately towards the satellites.

If a microcomputer is used, it can also receive or transmit programs.

In this multimedia application example, a telephone or facsimile line 38 and a TV or radio receiver 40 are also connected via a connector or distributor 36.

Figure 2 shows a more detailed example of an antenna 24 with radiating elements 28 and 30. In this embodiment, a fixed lens 42 receives microwave radiation

within a solid angle of sufficient size to collect signals from non-geostationary satellites in the user's field of view. The lens focuses received radiation onto a spherical surface over which the radiating elements 8 and 30 move. The lens 42 is supported by two uprights of which only one upright 44 can be seen in Figure 2.

The radiating elements 28 and 30 can move over the spherical focusing surface 26. Two motors and two arms are provided for each element for this purpose. For simplicity, only the motors and arms for the radiating element 28 are described.

The radiating element 28 is moved by a first motor 46 fastened to a bottom support 48 and whose output shaft rotates an arm 50 at the end of which is a second motor 52 in turn driving a forearm 54 at the end of which is the radiating element 28. The motors 46 and 52 for moving the radiating element 28 are controlled by information supplied by the microcomputer 34 or the like.

Each radiating element 28, 30 is associated with a transceiver circuit described later with reference to Figure 5.

Because the terminals 18 are consumer products, it is essential that they are small in size, low in weight and of minimum cost. The need for low weight and small size is reinforced by the fact that the transceiver devices are mobile and are associated within a small volume, i.e. that of the antenna 24.

This minimal size, weight and price must be compatible with the high performance necessitated in particular by the high bit rate of the information and simultaneous transmission and reception. From this point of view, isolating transmit and receive signals is a difficult problem, especially in the above-mentioned context of small size and low cost.

In the present example, the receive band Rx is from 11.7 GHz to 12.45 GHz (and can be extended up to 12.55 GHz) and the transmit band Tx is from 14 GHz to

14.3 GHz. The transmit power is a few watts, in the order of 2 W to 3 W.

The radiating element of the invention is a planar element. In the example shown in Figure 3, it comprises
 5 a circular patch 60 truncated by two parallel lines 62 and 64. The patch 60 is associated with two microstrip ports 66 and 68 at 90° to each other. The two ports 66 and 68 are excited by signals with a relative phase difference of 90°. The port 66 is a receive port and is
 10 connected to a low-noise amplifier 70. The port 68 is a transmit port and is connected to a power amplifier 72.

Exciting the ports 66 and 68 with signals having a relative phase difference of 90° produces transmit and receive signals which are circularly polarized in
 15 opposite directions. In conjunction with the separate frequency bands of the signals, the orthogonal polarizations of the transmit and receive signals produce around 20 dB of isolation between the signals. The planar technology used for the radiating element
 20 minimizes its cost, size and weight. Furthermore, the implementation with two direct ports minimizes the number of components and eliminates the need for the wideband hybrid coupler or circulator used in the variants shown in Figure 3a (circulator) and Figure 3b (hybrid coupler).

25 In the example shown in Figure 3a, a truncated circular plane patch 74 has a port connected to the output of the power amplifier 72₁ (transmit circuit) via a circulator 76. The port 78 is also connected to the receive channel, i.e. to a low-noise amplifier 70₁, via
 30 the same circulator 76. Although this implementation is less advantageous from the cost and size points of view, it has the advantage that it is simple to implement.

In the Figure 3b example, a non-truncated circular planar radiating element 80 has two orthogonal ports 82
 35 and 84 connected to respective terminals 86 and 88 of a hybrid coupler 90 having two other terminals 92 and 94. The terminal 92 is connected to the input of the low-

noise amplifier 70₂ and the terminal 94 is connected to the output of the power amplifier 72₂. The 90° hybrid coupler converts orthogonal linear polarizations at the terminals 92 and 94 into circular polarizations in opposite directions at the terminals 86 and 88. Accordingly, the signals at the ports 82 and 84 have circular polarizations in opposite directions. The hybrid coupler 90 is preferably of the wideband type. To this end, one or more additional microstrip branches 96 are provided.

Although, compared to the embodiment shown in Figure 3, this variant is larger, it has the advantage of being reliable in operation and of providing very satisfactory isolation between transmit and receive signals.

One embodiment of the transceiver device using a planar patch that is preferable for use in the Figure 3 embodiment will now be described with reference to Figure 4. It can also be used in the Figure 3a and 3b variants.

In this example there are two superposed planar patches 98 and 100. The shape of each patch corresponds to that shown in Figure 3, i.e. a truncated circle. The dimensions of the patches are different, however. The bottom patch 98 has dimensions corresponding to resonance in the receive band and the top patch has smaller dimensions corresponding to resonance in the transmit band (higher frequencies).

The two patches have a relative arrangement such that they have a common central axis (perpendicular to their plane) with their truncation lines parallel.

The ports 102 are under the bottom patch 98. Only one port can be seen in Figure 4. The ports use the microstrip or suspended triplate technology. They are connected to the filter circuits and to the low-noise or power amplifiers by microstrip or triplate lines. In this example the filter and matching means also use the microstrip or triplate technology.

The patches and the ports are disposed in a

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cylindrical cavity 110 open at the top and having a bottom 112.

The cavity 110 limits a relatively narrow microwave transmit and receive cone directed towards the satellite

5 12.

The bottom of the cavity is connected to a channel 114 whose axis is perpendicular to the axis 116 of the central cavity 110. The channel contains a substrate 118 carrying the ports 102 and microstrip or triplate filter and matching circuits 120. The substrate also has active components such as amplifier transistors 122 at the opposite end of the channel 114 to the cavity 110. A sealing wall 124 separates the end part of the planar microstrip technology channel 114 including the

10 15 transistors 122 from the circuits 120, which are preferably implemented in the suspended triplate planar technology.

The end of the channel 114 comprises a receive signal terminal 128 and a transmit signal terminal 130.

20

The opening 132 at the top of the cavity 110 is closed by a protective cap 134 made from a plastic material such as PTFE or ABS.

Alternatively (not shown), the ports are on one of the patches, for example the patch 98.

25

It is equally possible to provide a single patch with ports on the patch or at a distance from it.

A filter and amplifier circuit in accordance with the invention which minimizes noise, in particular that generated by filtering, whilst reducing the cost of implementing the circuits will now be described with

30 reference to Figure 5. Losses are also minimized.

Because transmission and reception are simultaneous, filtering out transmit frequencies in the receive circuits and receive frequencies in the transmit circuits

35 must be particularly efficient.

To this end, in accordance with the invention, each circuit includes planar filters and multistage

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amplification and filtering. The attenuation, or
rejectivity, of the filter nearest the radiating element
is a fraction of the attenuation needed to eliminate the
frequencies to be eliminated. In one example, the total
5 rejectivity needed to eliminate the transmit (or receive)
frequencies is in the order of 50 dB and the rejectivity
of the first (or last) stage filter is only in the order
of 14 dB. This value is calculated as a function of the
compression point of the first receive (amplifier)
10 transistor (or the noise factor of the last transmit
(amplifier) transistor), the power to be transmitted or
the isolation between the two ports of the source
(radiating element).

The amplification provided by the first stage of
15 amplification is a fraction of the total gain.

This minimizes the noise seen by the radiating
element. This is because this noise depends mostly on
the noise due to the amplification stage and the filter
nearest the element. In contrast, the noise introduced
20 at the radiating element by amplifier and filter stages
that are farther away is reduced in proportion to the
gain of the intermediate amplifier stages between the
radiating element and the filter generating the noise.

What is more, planar filters having a moderate
25 rejectivity can be easily implemented at moderate cost
because low-cost substrates can be used. Planar
microstrip (or suspended triplate) technology filters for
high rejectivities require relatively costly alumina
substrates, but for lower rejectivities it is possible to
30 use lower cost substrates, for example substrates based
on PTFE (see below).

In the example shown in Figure 5, the receive
circuit comprises a first part 140 between the port 142
of the patch 144 of the radiating element and an end of a
35 cable 146. It has a second part 148 between the other
end of the cable 146 and the demodulator (not shown) of
the receive circuit.

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The port 142 is connected directly to the input of a first filter 150 of the band-pass type for receive frequencies and of the band-stop type for transmit frequencies. For transmit frequencies it has a moderate rejectivity (14 dB). For receive frequencies its attenuation (or loss) is low, in the order of 0.2 dB. The first filter 150 is connected to the input of a first amplifier stage 152 which in this example comprises a single transistor. The amplifier 152 has a gain of 8 dB in this example. Note that this gain of 8 dB is not the maximum gain that could be obtained with one transistor. However, in this example, noise is minimized to the slight detriment of the gain, as explained below with reference to Figure 6.

The first part 140 of the receive circuit also includes a second stage filter-amplifier pair comprising a filter 154 whose input is connected to the first amplifier 152 and a second amplifier 156 which also comprises a single transistor in this example. The filter 154 has a rejectivity of 10 dB for transmit frequencies and a low rejectivity (0.2 dB) for receive frequencies. The amplifier stage 156 has a gain of 10 dB.

In this example the level of the unwanted transmit signal at the output of the stage 156 is below 10 dBm.

The cable 146, which introduces an attenuation of 1.5 dB in this example, is connected to the filter and amplifier second part 148 which comprises a third filter-amplifier pair 158-160. The filter 158 receives the signal supplied by the cable 146 and delivers a signal to the third amplifier 160. The attenuation of the filter 158 is 26.5 dB for transmit frequencies and 1.8 dB for receive frequencies. The amplifier stage 160 includes two transistors and its gain is 18 dB.

All unwanted transmit signals have been filtered out from the signal obtained at the output of the stage 160, which is conventionally connected to a mixer 162

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receiving a 10.75 GHz local oscillator signal at another input. The output of the mixer 162 is connected to the receive demodulator via a low-pass filter 166.

5 The attenuation of unwanted frequencies by each filter is matched to the gain of the associated amplifier so that it is sufficient to prevent unwanted transmit signals delinearizing or saturating the transistor(s) of the amplifier (this is referred to as compression). Each
10 filter must therefore be upstream of the associated amplifier, i.e. the filter must be nearer the radiating element than the amplifier of the same pair.

The overall noise factor of the receive circuit is essentially that of the first stage (filter 150 and amplifier 152).

15 In this embodiment the coaxial cable 146 and the corresponding coaxial cables 170 and 172 for the transmit circuit form a loop around the motors which can be reeled in or paid out as the arms move.

20 The second part 148 of the receive circuit (and the corresponding part of the transmit circuit) are at the bottom of the antenna in this example, i.e. near the base 48 (Figure 2).

25 The first part 142 of the receive circuit is implemented in the "hybrid without adjustment" technology, which means that active components such as transistors are deposited directly onto a substrate, with no packaging, and that the substrate has planar, for example photo-etched, conductors. This implementation
30 minimizes the noise factor, i.e. it maximizes the signal to noise ratio. The weight and overall size are also minimized.

35 In contrast, the part of the circuit 148 which is at the bottom of the antenna, and which is therefore farther away from the radiating element, can be made more conventionally using an integrated technology such as the MMIC (Microwave Monolithic Integrated Circuit) technology. As already indicated, the noise introduced

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by the stage 148 makes little contribution to the overall noise factor. Similarly, the losses of the filter 158 with the higher rejectivity (26.5 dB in this example), which avoids compression, i.e. delinearizing the transistors of the stage 160, is also less critical than for the part 140.

In the part 140, the substrates are Rogers Corporation RO 3006 or RO 4003 substrates, for example. They comprise a matrix of flexible organic material such as PTFE (polytetrafluoroethylene) reinforced with glass microfibers and charged with ceramic particles which increase the dielectric constant and therefore reduce the size of the circuits. One side of the substrate is coated with a copper layer which constitutes the earth and the other side is covered with copper which is photo-etched to form the circuits.

The transmit circuit is analogous to the receive circuit. The transmit port 180 of the patch 144 is connected to the output of a first filter 182 whose input is connected to the output of an amplifier stage 184. The attenuation of the filter 182 is 14 dB for receive frequencies and 0.2 dB for transmit frequencies. The gain of the amplifier 184 is 8 dB.

The input of the amplifier 184 is connected to an output of a filter 186 receiving the output signal of an amplifier stage 188. The attenuation of the filter 186 is 10 dB for receive frequencies and 0.2 dB for transmit frequencies. The gain of the amplifier stage 188 is 8 dB.

The other part of the transmit circuit is also at the bottom of the antenna, near the base 48 (Figure 2), and includes a filter 190 connected to the cable 170 or 172 via a switch 173. The filter 190 receives the output signal of an amplifier stage 192 including four transistors. The attenuation of the filter 190 is 30 dB for receive frequencies and 1.8 dB for transmit frequencies. The gain of the amplifier 192 is 32 dB.

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The input of the amplifier 192 is connected to the output of a mixer 194 via a filter 196. The mixer has two inputs which are conventionally connected to a transmit modulator (not shown) and a 13.05 GHz transmit local oscillator.

For the transmit circuit, the advantage of the division into stages is that the last stage, connected directly to the port 180, has low losses because of the low rejectivity of the filter 182 and the relatively low gain of the stage 184.

The cable 172 is connected to the circuits associated with the second radiating element (not shown). In other words, the part of the transmit circuit with the switch 173, filter 190, amplifier 192, filter 196 and mixer 194 is common to the two radiating elements. The other parts of the circuit are individual to each radiating element.

Figure 6 shows a particularly simple and efficient embodiment of the first part 140 of the receive circuit. The first part (182, 184, 186, 188) of the transmit circuit can be implemented in an analogous manner; it is therefore not described in detail.

The filters 150 and 154 are an important feature of this embodiment.

These filters must have low-loss band-pass characteristics for receive frequencies and high attenuation band-stop characteristics for transmit frequencies.

Each filter comprises at least one etched planar conductive member which is transverse to the current propagation etch 200 in this example. Thus the filter 150 has an elongate rectangular first etch 202 perpendicular to the etch 200 and terminating in a standard open circuit. The filter 150 also has a second etch 204 or stub branching from the line 200. The stub 204 terminates in a "pseudo short circuit" simulated by a wide capacitative section 206. This avoids a connection

to earth via plated-through holes.

The stub 202 terminating in an open circuit must have a length \underline{l} such that there is an open circuit where it joins the main line 200 for transmit frequencies and a short circuit for receive frequencies.

The length \underline{l} must be a multiple of $\lambda/2$ for wavelengths λ corresponding to receive frequencies and a multiple of $\lambda/4$ for wavelengths corresponding to transmit frequencies.

To achieve this objective, the length \underline{l} is made equal to $\lambda_d/4$, where λ_d is a wavelength corresponding to a frequency f_d equal to the difference $f_t - f_r$ between two frequencies f_t and f_r , f_t is a frequency in the transmit band and f_r is a frequency in the receive band. The frequencies f_d , f_t and f_r are also chosen to satisfy the following equations:

$$f_t = (2m + 1)f_d$$

$$f_r = 2mf_d$$

In the above equations, m is a positive integer.

The length \underline{l} is therefore a multiple of $\lambda/4$ for transmit frequencies and a multiple of $\lambda/2$ for receive frequencies. Under these conditions, the element 202 constitutes a short circuit for receive frequencies and an open circuit for transmit frequencies.

The stub 204 terminated by the wide capacitative section 206 simulating a short circuit at the junction 204-206 must have a length \underline{l}' chosen so that the element constitutes a short circuit for transmit frequencies and an open circuit for receive frequencies. A length \underline{l}' of $\lambda_d/4$ is chosen where λ_d corresponds to a frequency $f_d = f_t - f_r$ and where:

$$F_t = 2mf_d$$

$$F_r = (2m - 1)f_d$$

All the embodiments achieve the required result, namely high attenuation of transmit frequencies and transmission of receive frequencies without interference.

In the example for which the Rx band is from

11.7 GHz to 12.45 GHz and the Tx band from 14 GHz to 14.3 GHz, and in the case of the stub 204 terminated by a pseudo short circuit, the frequencies f_r , f_t and f_d can be chosen as follows:

$$\begin{aligned} f_r &= 11.75 \text{ GHz} \\ f_t &= 14.1 \text{ GHz} \\ f_d &= f_t - f_r = 2.35 \text{ GHz} \\ f_r &= 5f_d \\ f_t &= 6f_d \end{aligned}$$

For the element 202 terminating in an open circuit, the frequencies f_r , f_t and f_d are chosen so that f_r is an even multiple of f_d and f_t is an odd multiple of f_d .

Note that the filter element 202 can be used on its own without the filter element 204-206 or the filter element 204-206 can be used on its own without the element 202 or, finally, as shown, the two filter elements can be used simultaneously.

The amplifier stage 152 includes a transistor 208 and electrode polarization and impedance matching etches. In this example, the transistor 208 is a Fujitsu FHX13X. Its gate is connected to the line 200 via a rectangular etch 210. The bias is applied to a square etch 212 for the gate and a square etch 214 for the drain.

The stage 152 is connected to the filter stage 154 via a capacitor 216 for matching and decoupling the bias voltages at the terminals 212 and 214.

The source of the transistor 208 is connected to earth via an inductor 220 providing feedback and consisting of a wiring or connection strip or wire. The inductance of the inductor 220 is optimized to minimize noise. Minimizing the noise can reduce the gain, but this effect is slight and does not degrade amplification performance.

CLAIMS

1. A circuit for receiving (or transmitting) microwaves, the circuit comprising radiating means (60; 74; 80; 144) for receiving (or transmitting) microwaves, filter means
5 for eliminating microwaves transmitted (or received) at different frequencies by the radiating means, and means for amplifying received (or transmitted) microwaves, characterized in that it includes at least two filter and amplifier stages (150, 152, 158, 160; 182, 184, 190, 192)
10 connected to the radiating means and respectively comprising a planar filter (150, 158; 182, 190) whose rejectivity for transmit (or receive) frequencies is a fraction, preferably a small fraction, of the total rejection needed to eliminate the transmit (or receive)
15 frequencies and an amplifier (152, 160; 184, 192) whose gain is a fraction of the total gain of the circuit, said filter and amplifier stages applying progressive filtering and amplification.
2. A circuit according to claim 1, characterized in that
20 the planar filter (150; 182) of the first (or last) stage (150, 152; 182, 184) is connected directly to the radiating means.
3. A circuit according to claim 1 or claim 2, characterized in that the attenuation of the filter (150;
25 182) of the first (or last) stage (150, 152; 182, 184) and the gain of the amplifier (152; 184) of that stage have values such that the amplifier is not delinearized by residual transmit (or receive) signals not eliminated by the associated filter.
- 30 4. A circuit according to any of claims 1 to 3, characterized in that the total rejectivity needed to eliminate the transmit (or receive) frequencies is in the order of 50 dB and the rejectivity of the filter (150; 182) of the first (or last) stage (150, 152; 182, 184) is

in the order of 14 dB.

5. A circuit according to any preceding claim,
characterized in that the amplifier (152; 184) of the
first (or last) stage (150, 152; 182, 184) comprises at
least one transistor, that stage is of hybrid form and
the transistor comprises a semiconductor die with no
packaging disposed on the substrate on which the planar
filter is implemented.
6. A circuit according to claim 5, characterized in that
the stage (158, 160; 190, 192) farthest from the
radiating means is in the form of an integrated circuit,
for example an MMIC.
7. A circuit according to claim 6, characterized in that
the radiating means are mobile, the first (or last) stage
(150, 152; 182, 184) is also mobile and the stage
implemented in the form of an integrated circuit is
immobile.
8. A circuit according to any preceding claim,
characterized in that the substrate for the planar filter
(150; 182) of the first (or last) stage (150, 152; 182,
184) has a matrix of a flexible organic material such as
PTFE.
9. A circuit according to claim 8, characterized in that
the substrate contains glass fibers for mechanical
reinforcement and a dielectric, for example ceramic,
filler.
10. A circuit according to any preceding claim,
characterized in that it includes three filter and
amplifier stages (152, 154, 156, 158, 160; 182, 184, 186,
188, 190, 192) and the filter (158; 190) farthest from
the radiating means has a higher attenuation than the

filters of the other two stages.

11. A circuit according to claims 5 and 10, characterized in that the intermediate filter and amplifier stage (152, 154; 186, 188) is in hybrid form with a transistor
5 comprising a semiconductor die with no packaging disposed on the substrate on which the planar filter is implemented.

12. A circuit according to claim 11, characterized in that the intermediate stage and the first (or last) stage
10 (150, 152; 182, 184) are made on the same substrate.

13. A circuit according to any preceding claim, characterized in that the amplifier (152; 184) of the first (or last) stage (150, 152; 182, 184) includes a field effect transistor (208) and in that a connecting
15 wire (220) connected to the source forms a feedback inductor with a value chosen to minimize noise.

14. A circuit according to any preceding claim, characterized in that receive frequencies are in the band from 11.7 GHz to 12.55 GHz and transmit frequencies are
20 in the band from 14 GHz to 14.3 GHz.

15. A circuit according to any preceding claim, characterized in that the microwaves transmitted and received are orthogonally polarized, in particular with circular polarizations in opposite directions.

16. A circuit according to any preceding claim, characterized in that the planar filter is implemented in the microstrip or suspended triplate technology.
25

17. The use of the circuit according to any preceding claim to a terrestrial telecommunications system terminal
30 which comprises a transceiver circuit for communicating

with another terrestrial terminal or a station providing services via a non-geostationary satellite.

18. A method of receiving (or transmitting) microwaves via radiating means, in which method filtering eliminates microwaves transmitted (or received) at different frequencies by the radiating means and the waves received (or to be transmitted) are amplified, characterized in that the filtering and amplification are progressive, the first (or last) filtering stage, starting from the radiating means, uses a planar filter whose rejectivity is a small fraction of that needed to eliminate transmit (or receive) frequencies throughout the corresponding system and the first (or last) stage amplifier gain is a small fraction of the total necessary gain.

19. A method according to claim 18, characterized in that the rejectivity of the first (or last) filter stage is determined as a function of the compression point of the amplifier (152; 184) of the first stage (150, 152; 182, 184) (or of the noise factor of the last stage of amplification), the power to be transmitted and the isolation between the two ports of the radiating means.

A B S T R A C T

A CIRCUIT FOR AND A METHOD OF RECEIVING OR TRANSMITTING
MICROWAVES

5

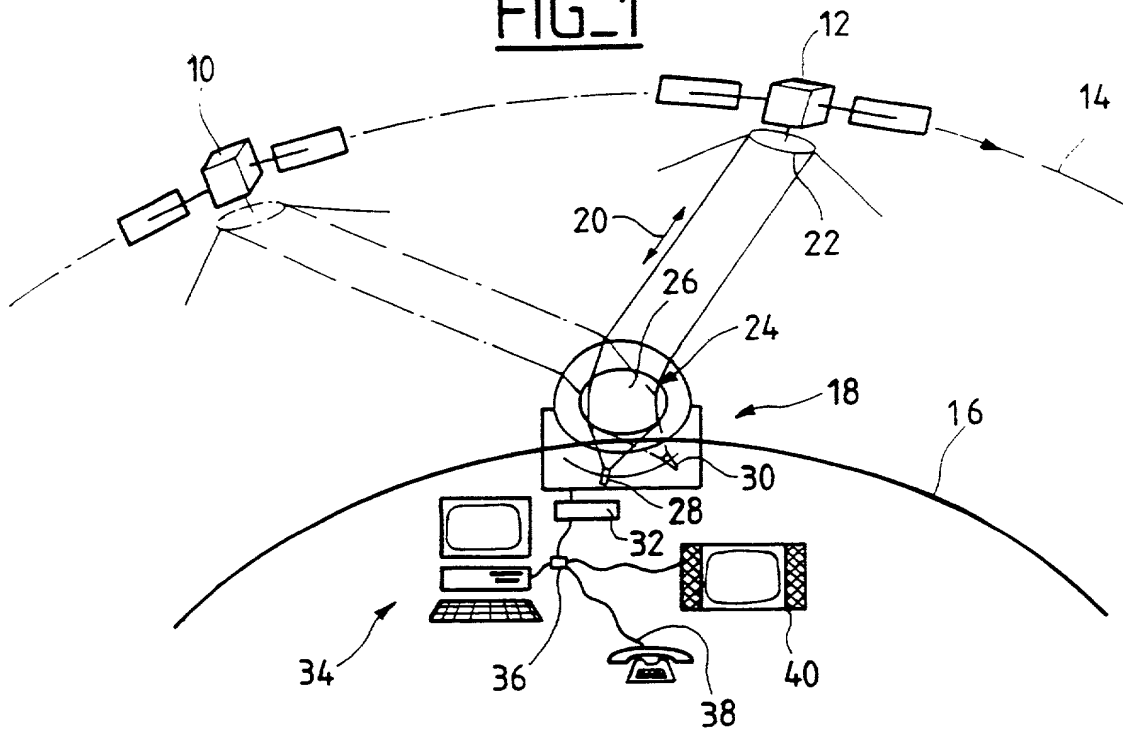
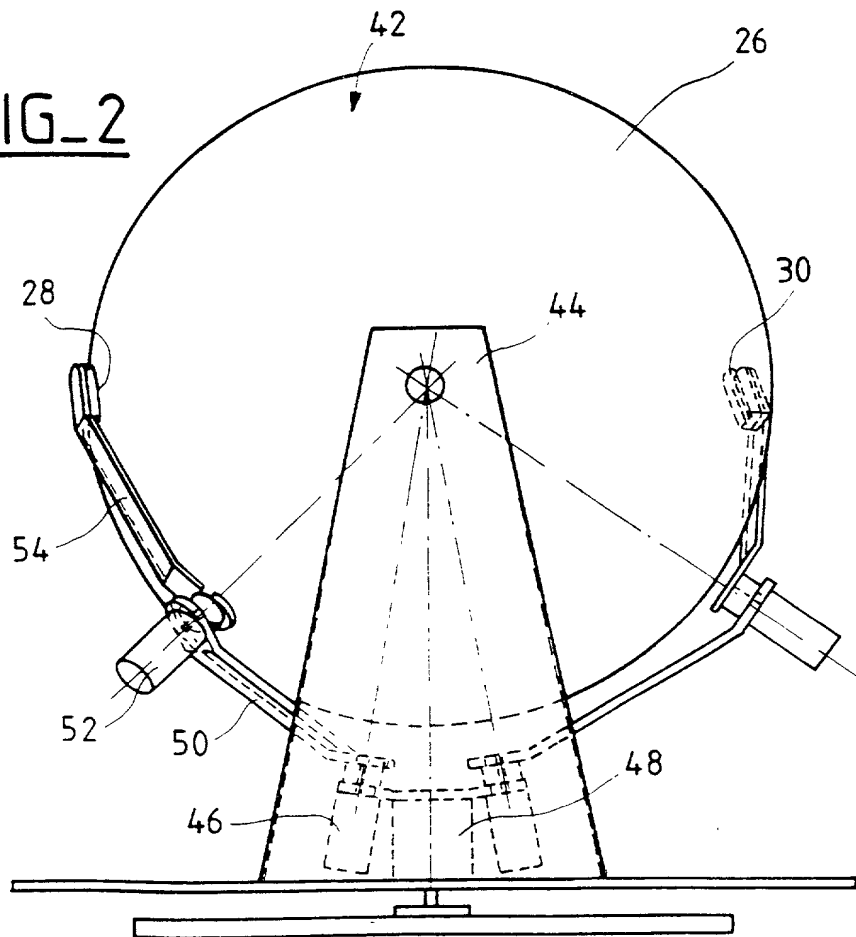
The invention relates to a circuit for receiving (or transmitting) microwaves, the circuit comprising radiating means (144) for receiving (or transmitting) microwaves, filter means for eliminating microwaves transmitted (or received) at different frequencies by the radiating means and means for amplifying the received (or transmitted) microwaves. The circuit includes a first (or last) stage (150, 152; 182, 184) connected to the radiating means comprising a planar filter (150; 182) whose rejectivity for transmit (or receive) frequencies is a fraction, preferably a small fraction, of the total rejectivity needed to eliminate transmit (or receive) frequencies and an amplifier (152; 184) whose gain is a fraction of the total gain of the circuit. The planar filter of the first (or last) stage is preferably connected directly to the radiating means. The noise seen by the radiating means is minimized.

25

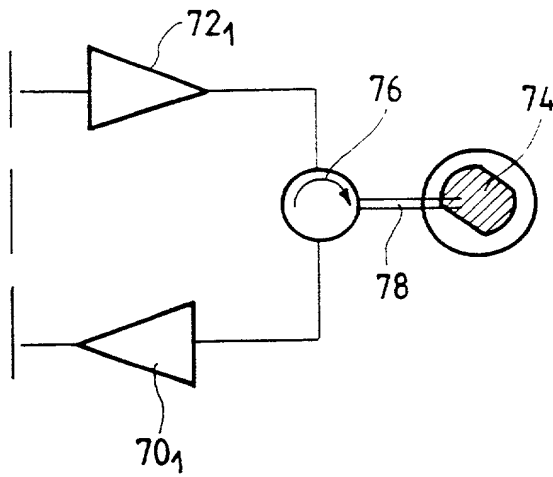
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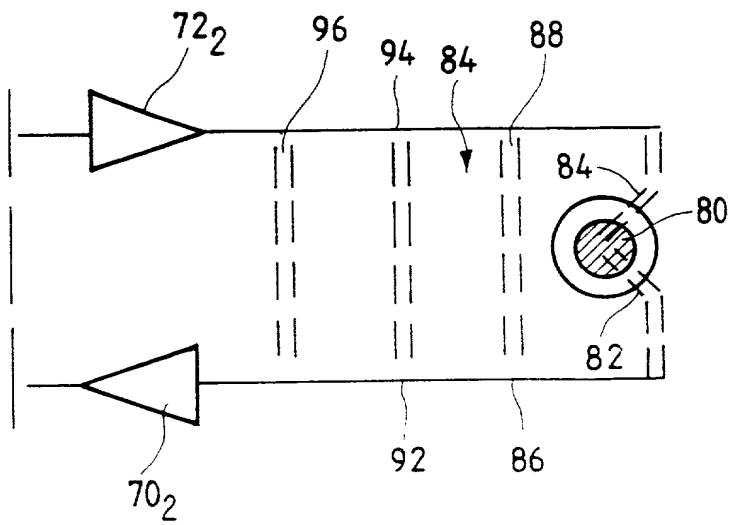
Translation of the title and the abstract as they were when originally filed by the Applicant. No account has been taken of any changes that may have been made subsequently by the PCT Authorities acting ex officio, e.g. under PCT Rules 37.2, 38.2, and/or 48.3.

FIG_1FIG_2

FIG_3a



FIG_3b



FIG_3

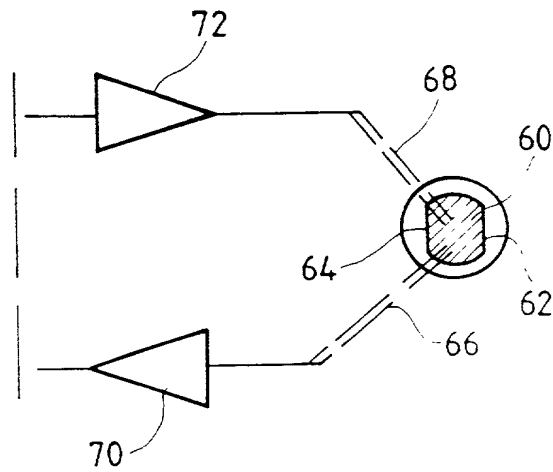


FIG-4

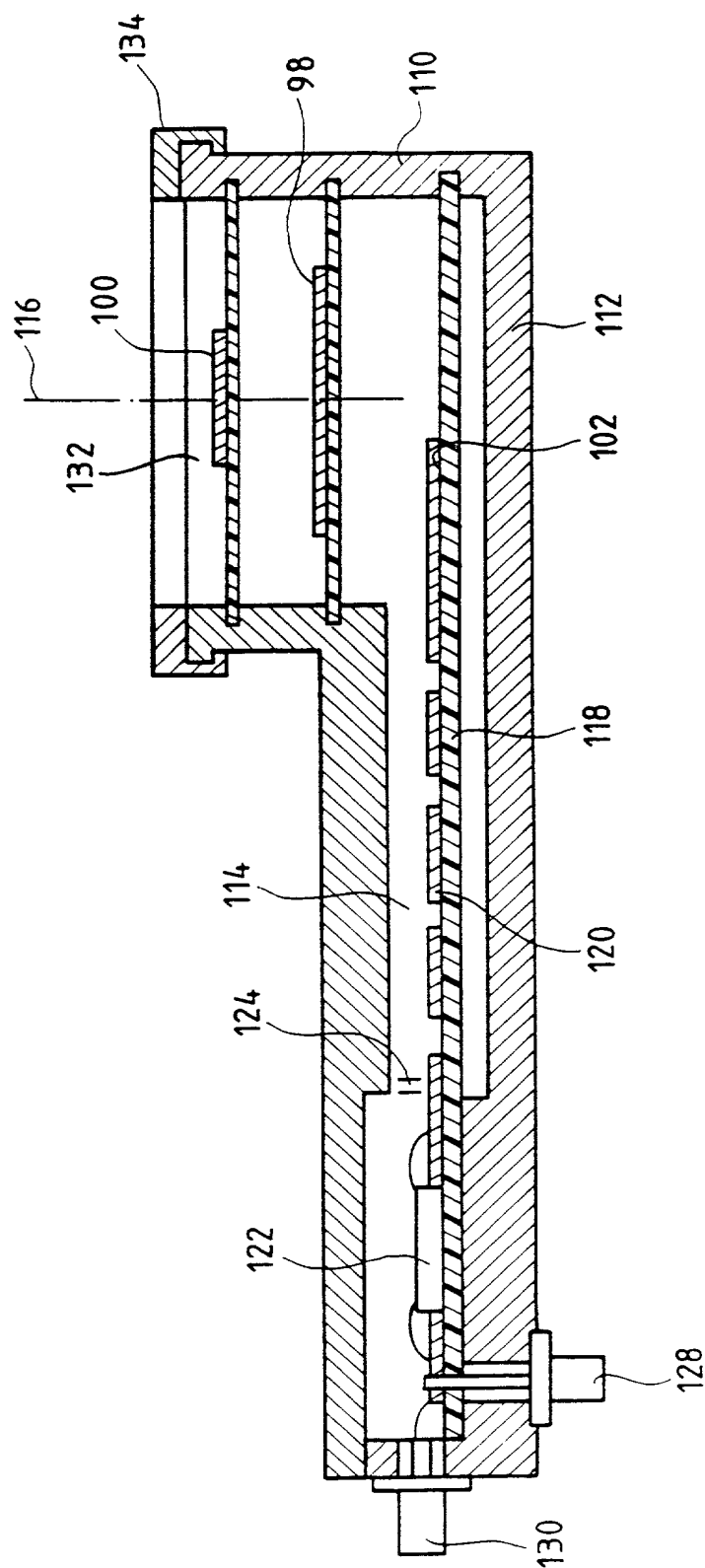


FIG-5

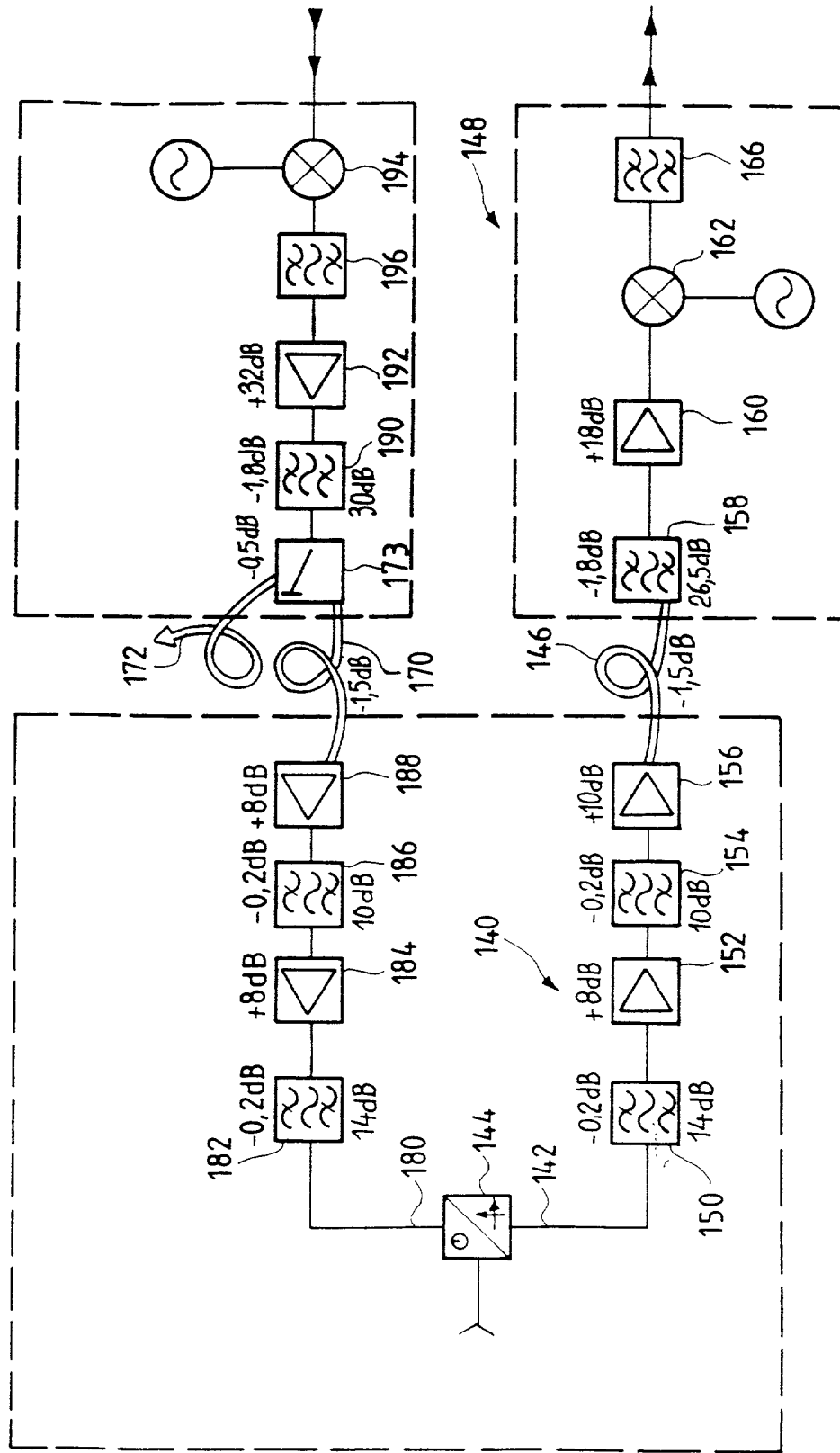
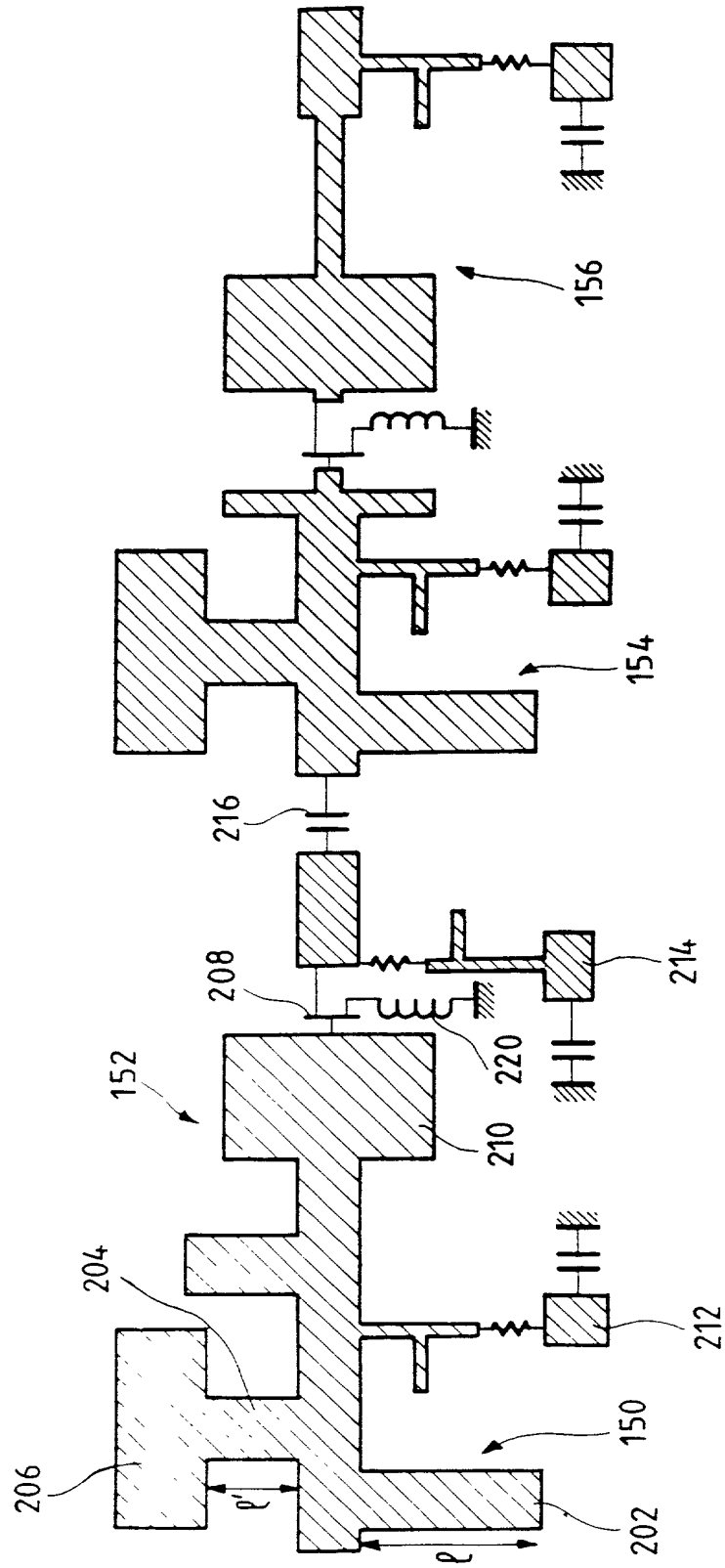


FIG-6



Declaration and Power of Attorney for Patent Application

Déclaration et Pouvoirs pour Demande de Brevet

French Language Declaration

En tant que l'inventeur nommé ci-après, je déclare par le présent acte que :

Mon domicile, mon adresse postale et ma nationalité sont ceux figurant ci-dessous à côté de mon nom.

Je crois être le premier inventeur original et unique (si un seul nom est mentionné ci-dessous), ou l'un des premiers co-inventeurs originaux (si plusieurs noms sont mentionnés ci-dessous) de l'objet revendiqué, pour lequel une demande de brevet a été déposée concernant l'invention intitulée

et dont la description est fournie ci-joint à moins que la case suivante n'ait été cochée :

☐ a été déposé le _____
sous le numéro de demande des Etats-Unis ou le numéro
de demande international PCT
_____ et modifié le
_____ (le cas échéant)

Je déclare par le présent acte avoir passé en revue et compris le contenu de la description ci-dessus, revendications comprises, telles que modifiées par toutes modification dont il aura été fait référence ci-dessus.

Je reconnais devoir divulguer toute information pertinente à la brevetabilité, comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations.

As a below named inventor, I hereby declare that :

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole invent or (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A CIRCUIT FOR AND A METHOD OF RECEIVING OR TRANSMITTING MICROWAVES

the specification of which is attached hereto unless the following box is checked :

☒ was filed on **May 10, 1999**
as United States Application Number or PCT
International Application Number **PCT/FR99/01105**
and was amended on
_____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

(Page 1 of 3)

Burden Hour Statement : This form is estimated to take 0.4 hours to complete. Time will vary depending upon the needs to the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETE FORMS TO THIS ADDRESS. SEND TO : Commissioner of Patents and Trademarks, Washington, DC 20231.

French Language Declaration

Je revendique par le présent acte avoir la priorité étrangère, en vertu du Titre 35, § 119 (a)-(d) ou § 365 (b) du Code des Etats-Unis, sur toute demande étrangère de brevet ou certificat d'inventeur ou, en vertu du Titre 35 § 365(a) du même code, sur toute la demande internationale PCT désignant au moins un pays autre que les Etats-Unis et figurant ci-dessous et, en cochant la case, j'ai aussi indiqué ci-dessous toute demande étrangère de brevet, tout certificat d'inventeur ou toute demande internationale PCT ayant à une date de dépôt précédant celle de la demande à propos de laquelle une priorité est revendiquée.

Prior foreign application(s)
Demande(s) de brevet antérieur(s)

98 06201

FRANCE

(Number) (Country)
(Numéro) (Pays)

(Number) (Country)
(Numéro) (Pays)

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(Application N°.) (Filing Date)
(N° de demande) (Date de dépôt)

(Application N°.) (Filing Date)
(N° de demande) (Date de dépôt)

Je déclare par le présent acte tout bénéfice, en vertu du Titre 35, § 120 du Code des Etats-Unis, de toute demande de brevet effectuée aux Etats-Unis, ou en vertu du Titre 35, § 365(c) du même Code, de toute demande internationale PCT désignant les Etats-Unis et figurant ci-dessous et, dans la mesure où l'objet de chacune des revendications de cette demande de brevet n'est pas divulgué dans la demande antérieure américaine ou internationale PCT, en vertu des dispositions du premier paragraphe du Titre 35 § 112 du Code des Etats-Unis, je reconnais devoir divulguer toute information pertinente à ma brevetabilité, comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations, dont j'ai pu disposer entre la date de dépôt de la demande antérieure et la date de dépôt de la demande antérieure et la date de dépôt de la demande nationale ou internationale PCT de la présente demande :

(Application No) (Filing Date)
(No de demande) (Date de dépôt)

(Application No) (Filing Date)
(No de demande) (Date de dépôt)

Je déclare par le présent acte que toute déclaration ci-incluse est, à ma connaissance, véridique et que toute déclaration formulée à partir de renseignements ou de suppositions est tenue pour véridique; et de plus, que toutes ces déclarations ont été formulées en sachant que toute fausse déclaration volontaire ou son équivalent est passible d'une amende ou d'une incarcération, ou des deux, en vertu de la Section 1001 du Titre 18 du Code des Etats-Unis, et que de telles déclarations volontairement fausses risquent de compromettre la validité de la demande de brevet ou du brevet délivré à partir de celle-ci.

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Priority claimed
Droit de priorité revendiqué

15 May 1998

YES

(Day/Month/Year Filed)
(Jour/Mois/Année de dépôt)

(Day/Month/Year Filed)
(Jour/Mois/Année de dépôt)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Status)(patented, pending abandoned)
(Statut)(breveté, en cours d'examen, abandonné)

(Status)(patented, pending abandoned)
(Statut)(breveté, en cours d'examen, abandonné)

I hereby declare all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge, that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

French Language Declaration

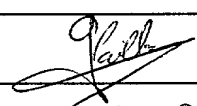

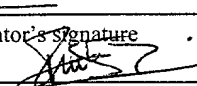

POUVOIRS: En tant que l'inventeur cité, je désigne par la présente l'(les) avocat(s) et/ou agent(s) suivant(s) pour qu'ils poursuive(nt) la procédure de cette demande de brevet et traite(nt) toute affaire s'y rapportant avec l'Office des brevets et des marques: (mentionner le nom et le numéro d'enregistrement).

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)

John H. Mion, Reg. No. ~~18,879~~; Thomas J. Macpeak, Reg. No. ~~19,292~~; Robert J. Seas, Jr., Reg. No. ~~21,092~~; Darryl Mexic, Reg. No. ~~23,063~~; Robert V. Sloan, Reg. No. ~~22,775~~; Peter D. Olexy, Reg. No. ~~24,513~~; J. Frank Osha, Reg. No. ~~24,625~~; Waddell A. Biggart, Reg. No. ~~24,861~~; Louis Gubinsky, Reg. No. ~~24,835~~; Neil B. Siegel, Reg. No. ~~25,200~~; David J. Cushing, Reg. No. ~~28,703~~; John R. Inge, Reg. No. ~~26,916~~; Joseph J. Ruch, Jr., Reg. No. ~~26,577~~; Sheldon I. Landsman, Reg. No. ~~25,430~~; Richard C. Turner, Reg. No. ~~29,710~~; Howard L. Bernstein, Reg. No. ~~25,665~~; Alan J. Kasper, Reg. No. ~~25,426~~; Kenneth J. Burchfiel, Reg. No. ~~31,333~~; Gordon Kit, Reg. No. ~~30,764~~; Susan J. Mack, Reg. No. ~~30,951~~; Frank L. Bernstein, Reg. No. ~~31,484~~; Mark Boland, Reg. No. ~~32,197~~; William H. Mandir, Reg. No. ~~32,156~~; Scott M. Daniels, Reg. No. ~~32,562~~; Brian W. Hannon, Reg. No. ~~32,778~~; Abraham J. Rosner, Reg. No. ~~33,276~~; Bruce E. Kramer, Reg. No. ~~33,725~~; Paul F. Neils, Reg. No. ~~33,102~~; and Brett S. Sylvester, Reg. No. ~~32,765~~; and Robert M. Masters, Reg. No. ~~35,603~~.

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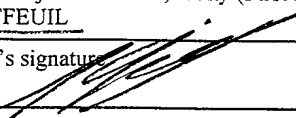
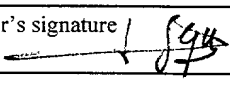
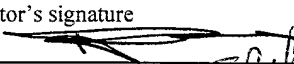
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SUGHRUE, MION, ZINN, MACPEAK & SEAS, PLLC
2100 Pennsylvania Avenue, N.W., Suite 800
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Nom complet de l'unique ou premier inventeur	Full name of sole or first inventor (First Middle Last) Gérard CAILLE
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Nom complet du second co-inventeur, le cas échéant	Full name of second joint inventor, if any (First Middle Last) Béatrice PINTÉ
Signature du second inventeur	Second inventor's signature  Date 2/10/99
Domicile	Residence LABEGE, FRANCE 
Nationalité	Citizenship FRENCH
Adresse postale	Post Office Address 6, route de Baziège 31670 LABEGE, FRANCE

(Fournir les mêmes renseignements et la signature de tout co-inventeur supplémentaire.)

(Supply similar information and signature for third and subsequent joint inventors.)

French Language Declaration

Nom complet du troisième co-inventeur, le cas échéant		Full name of third joint inventor, if any (First Middle Last) <u>Jacques GRAFFEUIL</u>	
Signature du troisième l'inventeur	Date	Third inventor's signature 	Date <u>26/04/99</u>
Domicile	<u>3W</u>	Residence <u>RAMONVILLE, FRANCE FR</u>	
Nationalité		Citizenship FRENCH	
Adresse postale		Post Office Address <u>28 Fontaine Cerdans</u> <u>31520 - Ramonville -</u>	
Nom complet du quatrième co-inventeur, le cas échéant		Full name of fourth joint inventor, if any (First Middle Last) <u>Jean-Guy TARTARIN</u>	
Signature du quatrième l'inventeur	Date	Fourth inventor's signature 	Date <u>20/09/99</u>
Domicile	<u>4W</u>	Residence <u>QUINT, FRANCE FR</u>	
Nationalité		Citizenship FRENCH	
Adresse postale		Post Office Address <u>81 route de la saune</u> <u>31130 QUINT. FONSEGRIVES</u>	
Nom complet du cinquième co-inventeur, le cas échéant		Full name of fifth joint inventor, if any (First Middle Last) <u>Thierry PARRA</u>	
Signature du cinquième l'inventeur	Date	Fifth inventor's signature 	Date <u>26/04/99</u>
Domicile	<u>5W</u>	Residence <u>TOULOUSE, FRANCE</u>	
Nationalité		Citizenship FRENCH	
Adresse postale		Post Office Address <u>24 Rue Duplessis</u> <u>31400 - Toulouse</u>	
Nom complet du sixième co-inventeur, le cas échéant		Full name of sixth joint inventor, if any (First Middle Last)	
Signature du sixième l'inventeur	Date	Sixth inventor's signature	Date
Domicile		Residence	
Nationalité		Citizenship	
Adresse postale		Post Office Address	